to carry the item. After waiting there for 10 to 15 minutes, we ceased our observations.

Collins (1976) suggests that caching behavior is an adaptive advantage when seasonal abundance of prey exists. Thus, by stockpiling food either during nesting or at other times of the year, the individual ensures an adequate food supply. This type of behavior has been documented in wild and captive raptors. Tordoff (1955) and Mueller (1974) probably have the most definitive work regarding food caching behavior by the American Kestrel *(Falco sparverius)*. Combined with known incidences of this behavior by the Peregrine *(Falco peregrinus)*, Goshawk *(Acipiter sp.)*, Secretary Bird *(Sagittarius serpentarius)*, Lizard Buzzard *(Kaupifalco monogrammicus)*, Brown and Amadon 1968), Prairie Falcon *(Falco mexicanus)*, (Oliphant and Thompson, 1976), and by a variety of tytonid and strigid owls (Collins 1976), one might consider this behavior to exist among all diurnal and nocturnal raptors.

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FLUCTUATIONS IN THE NUMBER OF NORTHERN HARRIERS *(CIRCUS CYANEUS HUDSONIUS)* AT COMMUNAL ROOSTS IN SOUTH CENTRAL OHIO

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Abstract

Eleven Northern Harrier *(Circus cyaneus)* roosts were studied in south central Ohio during the four winters of 1973–1974 through 1976–1977. They ranged from 8 to 59 birds. The number of birds using each roost fluctuated throughout the winter. While the abandonment of at least three roosts in midwinter can be attributed to severe weather, reciprocal fluctuations in the number of birds at nearby roosts and the direction of birds returning to one roost suggest that Northern Harriers will shift roost sites locally in an effort to maintain proximity to their hunting areas.

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Introduction

While the Northern Harrier *(Circus cyaneus)* is known to roost communally in Florida (Stoddard 1931), Indiana (Mumford and Danner 1974), Michigan (Craighead and Craighead 1956), Missouri (Weller et al. 1955), and New York (Clark 1972), there appears to be little quantitative data concerning their roosting behavior. This paper details fluctuations in the number of Northern Harriers at communal roosts in south central Ohio, noting especially the effect of the establishment of additional roosts nearby.

Methods

The study area was approximately 73 km^2 in south central Ohio along the Ross-Pickaway County line 16 km southeast of Circleville. The land is currently intensively farmed with little pristine habitat remaining except in small woodlots and along streams (Mills 1972). Small grain and livestock farms dominate the area.

From November to March 1973–1974 through 1976–1977 I found 11 communal harrier roosts, all that were present each winter (fig. 1), and estimated the number of birds using each. I rechecked each roost periodically (usually weekly and always within ten-day periods) to ascertain its size and status. Behavioral data were collected on six evenings and three mornings during the winter of 1973–1974 at one roost, on eleven evenings and five mornings during the winter of 1975–1976 at four roosts, and on six evenings and two mornings during the winter of 1976–1977 at three roosts. I spent 141.5 hours observing harrier pre- and post-roosting behavior.

During the winter of 1975–1976 I intensified my study and focused my efforts on roost 5 (see figure 1), following the behavior of its inhabitants from 9 November through 7 March. In the evening I arrived at roost 5 at approximately 85 min before sunset and stayed until after dark. For morning observations, I arrived 20 min before sunrise and remained until at least 100 min after sunrise. Observations were made from a pickup truck on a road or in a nearby field, usually at a distance of less than 0.25 km.

The flight directions of harriers leaving the roost in the morning and returning in the evening were noted. To reduce the possibility of recording a bird that was merely flying about, I recorded birds as approaching or leaving only if I was able to follow them for a flight distance of 0.5 km to or from the roost. I estimated the population of the roost by summing the number of birds seen entering or leaving the roost and comparing that number with the greatest number of birds seen over the roost at one time. The larger number was added to birds I intentionally flushed from the roost either prior to evening or following morning observations. Birds flushed from the roost in the evening quickly reroosted and were not counted twice in population estimates.

Results

Table 1 summarizes the number and species of birds using each roost and the period of time the roost was active. All roosts when initially found, usually in the fall or early winter, contained fewer than 20 birds.

Northern Harriers roosted with the Short-eared Owl *(Asio flammeus)* at seven of the eleven communal roosts. The remaining four roosts were small (each less than 15 birds) and did not remain active long (each less than one month). I also saw harriers roosting singly on the study area; these single bird roosts remained active for less than four nights.

Although there appeared to be no preference for high ground in the selection of roosts, roost 1 was abandoned when low-lying areas of the field were covered with melt water after a severe snow and ice storm. Similarly, roosts 9 and 10 were abandoned following a snowfall of 15–18 cm during the preceding 36 hours. Mois (1975) notes comparable weather-dependent roost abandonments in his study of *C.c. cyaneus* in Belgium. Harriers flew over these roost fields later in the winter, but my attempts to flush any from them were futile. In addition to those 3 roost abandonments, 5 of the remaining 8 communal roost sites were also deserted during midwinter before harriers left the study area. Moreover, all the communal roosts fluctuated in the number of birds using them, with the number of Short-eared Owls and Northern Harriers at a roost seeming to fluctuate independently. At roosts 2 and 5, 10–12 Short-eared Owls were present from mid-November through mid-December. Their numbers declined to 2 birds and remained so through early January. By late January there were 8–12 owls at each roost, and they remained there through the end of February. Fluctuations in the number of hawks using a roost, with one exception, followed one of two trends: either the number of birds at

Table 1. Description of Eleven Northern Harrier Roosts Studied

Roost number (winter)	Maximum number of birds using the roost		Minimum duration of roost activity
	Northern Harriers	Short-eared Owls	
1 (1973–1974)	40	12	12 Jan. 1974 to 19 Jan. 1974
2 (1974–1975)	30	12	30 Nov. 1974 to mid-March 1975
3 (1974–1975)	17	5	14 Dec. 1974 to 10 Jan. 1975
4 (1974–1975)	8	0	11 Jan. 1975 to 8 Feb. 1975
5 (1975–1976)	45	14	9 Nov. 1975 to mid-March 1976
6 (1975–1976)	12	0	10 Nov. 1975 to 30 Nov. 1975
7 (1975–1976)	25	4	2 Jan. 1976 to mid-March 1976
8 (1975–1976)	7	0	11 Jan. 1976 to 30 Jan. 1976
9 (1976–1977)	15	10	18 Nov. 1976 to 10 Jan. 1977
10 (1976–1977)	16	9	23 Dec. 1976 to 10 Jan. 1977
11 (1976–1977)	8	0	19 Feb. 1977 to mid-March 1977

the roost continued to increase slowly with a maximum number occurring in late winter, or the number of birds at the roost remained at less than 20 for several weeks, then declined rapidly to 5–10 birds that subsequently abandoned the roost *en masse.* The one exception was roost 5 which lost birds rapidly, but remained active for an additional 2 months.

Fluctuations in the number of harriers using roosts 5, 6, and 7 (fig. 2) show what happened when one of 2 neighboring roosts grew larger and when a new roost was established near an existing one. On 10 November 1975, roosts 5 and 6 were being used by 11 and 10 harriers, respectively. Twenty days later, roost 6 ceased to exist, and roost 5 almost doubled in size. Similarly, within 20 days of the establishment of roost 7, the number of birds estimated to be using roost 5 declined from 45 to less than 20. The same phenomeon occurred between roosts 2 and 3 during the winter of 1974–1975. With the establishment of roost 3 in mid-December 1974, roost 2 declined in numbers within 2 days from an estimated 25–30 harriers to 10–15 birds.

The establisment of a new roost was signalled by the birds drifting toward the new area in the evening. This pre-roosting behavior occurred over a broad band between the two roosts. At the time of actual roosting the birds separated and went to one or the other roost; there was no commingling in the morning during the predeparture period.

I monitored the direction of arrivals and departures at roost 5 before and after the establishment of roost 7, 1.4 km to the WSW (fig. 1). Before roost 7 was established, harriers departing from roost 5 dispersed randomly ($P > .10$; Kolmogorov test with Kuiper's adjustment for circular distributions; Batschelet 1965; Figure 3A). After roost 7 appeared, a Rayleigh test (Batschelet 1965) indicated a unimodal distribution of departures from roost 5 ($P < .01$) with a preferred departure direction to the ENE (mean direction 61°), opposite the direction of roost 7 (fig. 3B). Before roost 7 was established, although harriers returned from all directions a significantly greater proportion came from the SSE ($P < .01$; Rayleigh test; mean direction 156°; Batschelet 1965: Figure 4A). After the second roost appeared, the directional distribution of arrivals did not differ significantly from a uniform distribution ($P > .05$; Kolmogorov test with Kuiper's adjustment for circular distributions; Batschelet 1965; Figure 4B).

Discussion

While it is likely that severe weather caused abandonment of roosts 1, 9, and 10, all the communal roosts fluctuated in numbers. I suspect that these latter fluctuations reflected local prey availability. My observations strongly suggest that roost site selection results from a compromise among the birds using the roost. It appears that in the fall, as single birds arrive, they roost on or near the areas they hunt. As more birds arrive, the tendency to roost together leads birds to select communal roost sites equidistant from their hunting areas. The result is a general trend toward increasingly fewer roosts with more birds at each as the season progresses. Clark (1975) reports a similar seasonal progression in the size of the Short-eared Owl root he studied. Both Mumford and Danner (1975) and Weller et al. (1955) reported centrally placed roosts: The harriers they studied returned to communal roosts from all directions. Similarly Craighead and Craighead (1956) recorded Northern Harriers "fanning out each morning" from the roost they studied. Meinertzhagen (1956) notes a similar evening rendezvous for the communal roosting harriers *C. aeruginosus* and *C. pygargus* he watched. Thus, as long as the roost is central to a number of good hunting areas, it will continue to attract birds and increase in size. But as the winter progresses and prey becomes less readily available in certain hunting areas, harriers dispersing from the roost to those depleted areas will have to move elsewhere to hunt successfuly. This is supported by my observations of hunting harriers as well as those of Craighead and Craighead (1956) who found that winter ranges of harriers "approach a condition of continuous drift" when prey populations are low. The departure and arrival directions of harriers at roost 5 prior to the establishment of roost 7 illustrate this phenomenon. While birds were dispersing randomly from roost 5, I suspect some were flying into prey-depleted areas. These birds would be forced to move on in search of better hunting areas, the majority of which were apparently located SSE of the roost. This explains the nonrandom direction of birds returning to roost 5 prior to the establishment of roost 7. With the establishment of roost 7 (presumably by birds from roost 5) 1.4 km to the WSW, the direction of birds returning to roost 5 became random. Apparently some roost 5 birds, those whose hunting areas were to the south of roost 5, established a new roost (7) that was for them more central to their new hunting areas. The birds that remained in roost 5 did so because it was more centrally located to their hunting areas as is shown by the directions of returning birds. Morning departure directions from roost 5, which became nonrandom following the establishment of roost 7, possibly indicate that harriers departing from a roost tend to avoid other harriers departing from a second roost (7) nearby.

Acknowledgments

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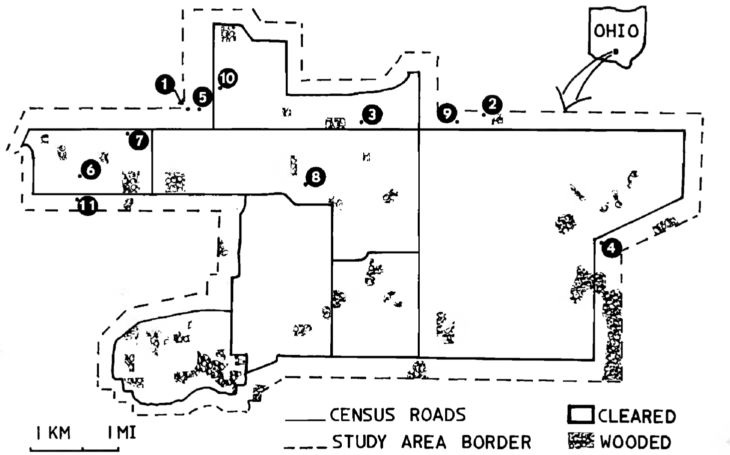

Figure 1.—Locations of the eleven Northern Harrier roosts studied. Harriers were seen hunting throughout the study area.

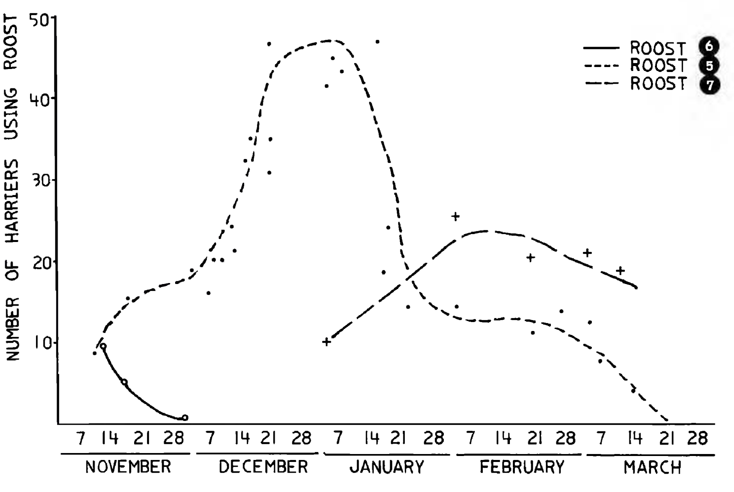

Figure 2.—Relation between the etablishment of a second Nothern Harrier roost nearby and the size of an existing roost.

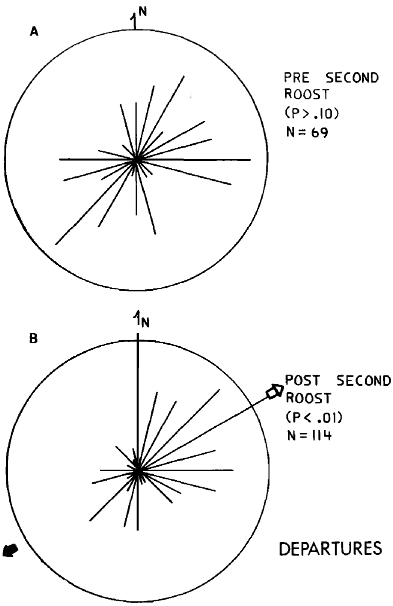

Figure 3—Directions of Northern Harriers departing from roost 5 before (A) and after (B) the establishment of roost 7. Filled arrow indicates direction of roost 7; open arrow indicates mean direction of a significant unimodal distribution. The circle represents a relative frequency of 10 percent. Probabilities of significance were found with a Rayleigh test (Batschelet 1965).

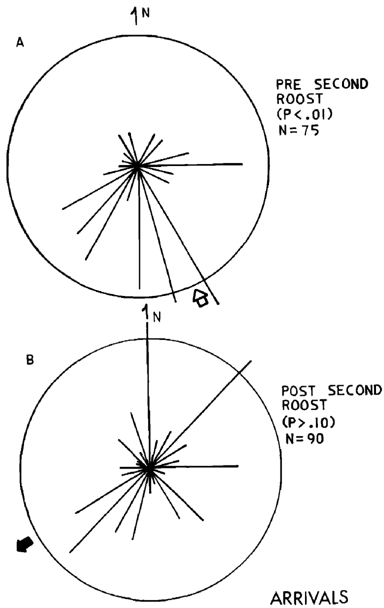

Figure 4—Directions of Northern Harriers arriving at roost 5 before (A) and after (B) the establishment of roost 7. Filled arrow indicates the direction of roost 7; open arrow indicates mean direction of a significant unimodal distribution. The circle represents a relative frequency of 10 percent. Probabilities of significance were found with a Rayleigh test (Batschelet 1965).